Advanced Research Center for Beam Science
– Laser Matter Interaction Science –

http://laser.kuicr.kyoto-u.ac.jp/e-index.html




Prof
SAKABE, Shuji
(D Eng)

Assoc Prof
HASHIDA, Masaki
(D Eng)

Assist Prof
TOKITA, Shigeki
(D Eng)

Proj Res*
OTANI, Kazuto
(D Sc)

* Program-Specific Res of Graduate School of Science

Students

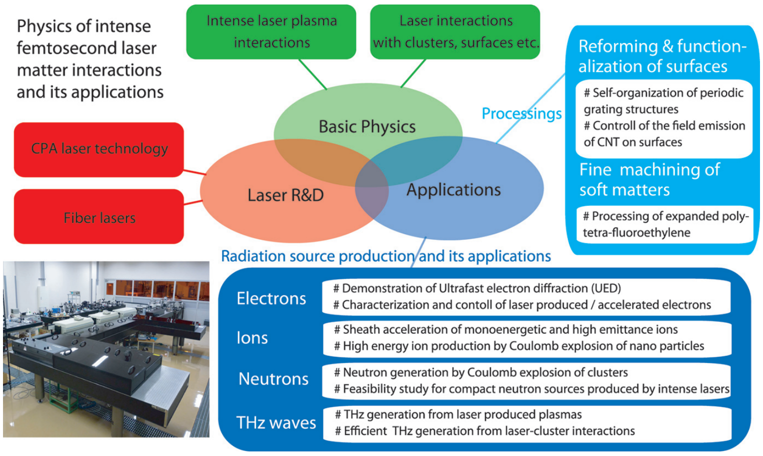
JAHANGIRI, Fazel (D3)
INOUE, Shunsuke (D2)
MIYASAKA, Yasuhiro (D1)
IKUTA, Yoshinobu (M2)
KOWATA, Kiyoto (M2)
NAKAJIMA, Hiroaki (M1)

Scope of Research

The interaction of femtosecond laser pulses with matters involves interesting physics, which does not appear in that of nanosecond laser pulses. Investigating the interaction physics, potential of intense femtosecond lasers for new applications is being developed (such as laser produced radiations and laser processing). Ultra-intense lasers can produce intense radiations (electrons, ions, THz, and so on), which can be expected as the next-generation radiation sources. Ultra-short lasers are available to process any matters without thermal dissociation. The femtosecond laser processing is also the next-generation laser processing. In our laboratory ultra intense femtosecond laser named T^6-laser is equipped, and the physics of intense laser matter interactions and its applications are researched.

KEYWORDS

Intense Laser Science
Laser Plasma Radiations
(Electrons, Ions, and THz)
Ultrafast Electron Diffraction (UED)
Laser Nano-ablation Physics
Femtosecond Laser Processing
Mid-infrared Fiber Lasers



Selected Publications

Jahangiri, F.; Hashida, M.; Tokita, S.; Nagashima, T.; Hangyo, M.; Sakabe, S., Directional Elliptically Polarized Terahertz Emission from Air Plasma Produced by Circularly Polarized Intense Femtosecond Laser Pulses, *Appl. Phys. Lett.*, **99,** 161505 (2011).

Otani, K.; Tokita, S.; Nishoji, T.; Inoue, S.; Hashida, M.; Sakabe, S., Efficient Laser-proton Acceleration from an Insulating Foil with an Attached Small Metal Disk, *Appl. Phys. Lett.*, **99,** 161501 (2011).

Inoue, S.; Tokita, S.; Otani, K.; Hashida, M.; Sakabe, S., Femtosecond Electron Deflectometry for Measuring Transient Fields Generated by Laser-accelerated Fast Electrons, *Appl. Phys. Lett.*, **99,** 31501 (2011).

Tokita, S.; Murakami, M.; Shimizu, S.; Hashida, M.; Sakabe, S., 12W Q-switched Er:ZBLAN Fiber Laser at 2.8 μm, *Opt. Lett.*, **36,** 2812-2814 (2011).

Tokita, S.; Otani, K.; Nishoji, T.; Inoue, S.; Hashida, M.; Sakabe, S., Collimated Fast Electron Emission from Long Wires Irradiated by Intense Femtosecond Laser Pulses, *Phys. Rev. Lett.*, **106,** 255001 (2011).

Hashida, M.; Miyasaka, Y.; Ikuta, Y.; Tokita, S.; Sakabe, S., Crystal Structures on a Copper Thin Film with a Surface of Periodic Self-organized Nanostructures Induced by Femtosecond Laser Pulses, *Phys. Rev. B*, **83,** 235413 (2011).

Hashida, M.; Sakabe, S.; Izawa, Y., Symmetric Charge-transfer Cross Sections of IIIa Rare-earth-metal Elements, *Phys. Rev. A*, **83,** 32704 (2011).

Mechanism for Crystal Structure Transformation on Metal Surface by Femtosecond Laser Pulses

The precise measurement for crystallinity degree was performed on cupper thin film with transmission electron microscope. We have analyzed the electron diffraction patterns in the laser fluence of 0.08–0.64 J/cm^2 where the grating structure is formed on thin films. It is found that the crystal structures are transformed depending on laser fluence; polycrystalline structures at <0.2 J/cm^2, amorphous at ~0.23 J/cm^2, and polycrystalline structures again at >0.35 J/cm^2. The mechanism of crystal structure transformation by femtosecond laser pulses is conceptually proposed, that is induced by the injection of energetic ions generated in the process of self-formation of periodic structures.

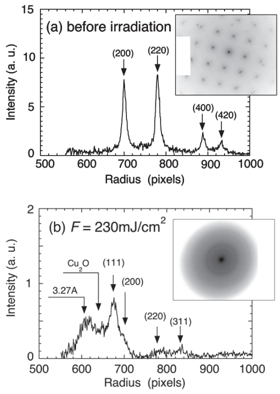


Figure 1. Electron diffraction patterns of thin Cu films (a) before irradiation and (b) at 0.23 J/cm^2.

Directional Elliptically Polarized THz Beam Emission from Air Plasma Produced by an Intense Femtosecond Laser Pulse

Terahertz (THz) radiation generated through the interactions of circularly polarized intense femtosecond laser pulses with air in the atmosphere has been studied. Strongly directional elliptically polarized THz emission in the forward direction is detected. The THz waves exhibits elliptical polarization with an ellipticity factor of 0–0.2 in the laser energy range of 10–50 mJ. The parametric decay of laser light to R-waves in plasma in the presence of an axial B field is proposed as a mechanism to interpret the experimental observations of the directionality, ellipticity, and energy dependence of the THz waves.

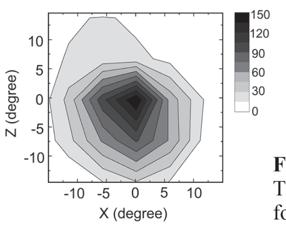


Figure 2. Typical spatial distribution of THz power emitted in forward direction for laser pulse energies of 50 mJ.

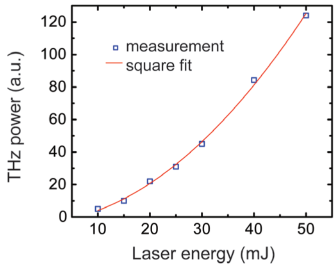


Figure 3. Laser pulse energy dependence of total THz power.

High-directivity Electron Emission from Laser-irradiated Wires

During the interaction of ultrahigh-intensity short laser pulses with solid targets, a large amount of electrons with kinetic energies of hundreds of kiloelectronvolts and higher are generated. Such electron sources have been extensively studied because of their potential applications. However, this electron source has a major problem: the electron emission generally shows little or no directivity. We have found experimentally that energetic electrons emitted from a metallic wire irradiated by an intense femtosecond laser pulse can be guided along the wire resulting in high directivity. This new electron source will be useful for many applications, because of high generation efficiency and high brightness, for instance the ultrafast electron diffraction, which needs short electron pulses in the sub-MeV energy range.

Figure 4 shows the experimental setup and results of angular distribution measurement of electrons. An imaging plate (IP) is used to detect the electrons with energies higher than 100 keV. The electrons form distinctive ring-shaped patterns on the IP. The overall size of the pattern is drastically reduced as the wire length L is increased. The FWHMs of the electron emission in the horizontal and vertical directions are as narrow as 20 and 65 mrad, respectively, at L=30 mm. The IP signal intensity increases with increasing the wire length: the signal intensity at the brightest spot for L=2.5 mm is 7-fold higher than that for L=2.5 mm. The total number of detected electrons is estimated to be of the order of 3×10^9 at L= 30 mm.

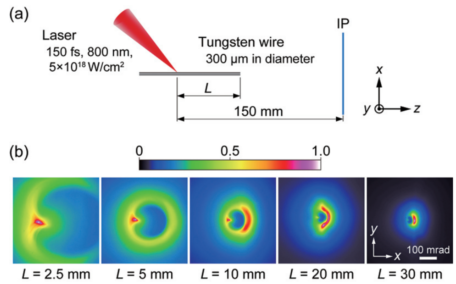


Figure 4. (a) Experimental setup for measurement of electron angular distribution. (b) Single-shot images detected by the IP. The color scale is set independently for each image for maximum contrast.